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Effect of Centenarian Gender on Survival of Centenarian Family Members

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Abstract

This study explores the effects of centenarian gender on survival of biological and non-biological relatives of 1,945 validated U.S. centenarians born in 1880-1895. Male gender of centenarian has significant positive effect on survival of adult male relatives (brothers and fathers) but not female relatives. Comparison of married siblings and siblings in law of centenarians found a strong positive effect of centenarian male gender on survival of brothers and a weak positive effect of female gender on survival of centenarian sisters compared to the same-sex siblings in law. Finally, wives of male centenarians had a significantly better survival compared to wives of centenarian brothers indicating importance of living conditions. This study suggests that environmental conditions and lifestyle may play more significant role in exceptional longevity than it was thought before. These results support the idea of early-life programming of human aging and longevity.

Background

Numerous studies show that biological relatives of centenarians have substantial survival advantage compared to relatives of shorter-lived individuals (Pearl & Pearl 1934; Gavrilova *et al.* 1998; Gavrilov & Gavrilova 2001; Kerber *et al.* 2001; Willcox *et al.* 2006; Perls *et al.* 2007). At the same time little is known about the role of centenarian gender in these effects. This study explores effects of centenarian gender on survival of their biological (parents and siblings) and non-biological (spouses and siblings in law) relatives.

Methods

Data Collection. This study compares centenarians to their parents (who share genetic background), siblings (who share common childhood conditions and genetic background), spouses (who share common adulthood environment) and siblings in law (who do not share genetic and environmental conditions but usually have a similar socio-economic background) using a large set of computerized family histories. Family histories (genealogies) proved to be a useful source of information for studies in historical demography (Adams & Kasakoff 1991) and biodemography (Gavrilov *et al.* 2002; Smith *et al.* 2002). In this study, data were collected through a search of over 400,000 online family histories available at Rootsweb (http://wc.rootsweb.ancestry.com), which is one of the largest publicly available repositories of online genealogies. Search for centenarians in the Rootsweb database was conducted with assistance of the web-automation technique (Sklar & Trachtenberg 2002), which allows researchers to run automated queries (using program scripts in PHP language) and search online databases for individuals with desired properties (persons who lived 100+ years in our case). Applying this technique helps researchers to save time and effort on routine data collection from online resources. Application of the web automation technique to the Rootsweb publicly available online resource identified over 40,000 records of centenarians born in 1880-1895 with known names of their parents. However, in many cases one and the same centenarian appeared in two or more genealogies. After removing these duplicates, we obtained 23,127 records for centenarians born in 1880-1895 with detailed information on their birth and death dates as well as birth and death dates of their parents. According to the past experience with computerized genealogies (Gavrilov *et al.* 2002), availability of detailed information on vital events ensures a good quality of collected genealogies. However, significant proportion of records for siblings in the obtained genealogies did not contain information about death dates that we needed for the within-family analysis of human longevity. So the next step was to indentify the most informative families with complete information on birth and death dates for siblings. As a result of this identification procedure, we found 2,834 families where information on birth and death dates was known for more than 80 percent of siblings in a family. This procedure resulted in a set of families having higher than average sibship size and hence providing more control records (siblings) for comparison. During this data refining procedure, the proportion of male centenarians in genealogies dropped from 28.2% to 23.2% and became close to the proportions reported in the U.S. censuses (19.3-24.0%) (Krach & Velkoff 1999), which indicates an improvement in quality for the selected genealogies.

Data Verification. Previous studies demonstrated that age misreporting and age exaggeration in particular are more common among long-lived individuals (Elo *et al.* 1996; Jeune & Vaupel 1999). Therefore, the primary focus of data cleaning in this study was on the age verification for long-lived individuals. We followed the approach of age verification and data linkage (Elo *et al.* 1996; Preston *et al.* 1996), which we applied previously on another dataset of centenarians (Gavrilova & Gavrilov 2007). This approach involves data consistency checks, death date verification through the linkage to the Social Security Administration Death Master File (DMF) and birth date verification through the linkage to early U.S. censuses. DMF is a publicly available data resource (available at the Rootsweb.com website), which covers deaths that occurred in the

period 1937-2010 and captures about 95% of deaths recorded by the National Death Index (Sesso *et al.* 2000). More details about the procedure of centenarian age validation were published elsewhere (Gavrilova & Gavrilov 2007). Validation of centenarian death and birth dates produced 1,711 centenarians. Information on siblings and spouses of validated centenarians was collected using the web automation technique described earlier.

We used only those records of centenarians whose age was successfully confirmed through the DMF (with matched birth and death years). We added only few cases where death year was different from that found in the DMF (however, in these cases the individual still had a centenarian status). Our previous work with centenarian data cleaning showed that incorrect death dates was the main source of errors in genealogical records of centenarians (Gavrilova & Gavrilov 2007). At the same time, birth dates were correctly reported in practically all records that had correct death dates and good consistency of birth and death dates for parents and siblings. Therefore, in this study we conducted a birth date verification procedure for a portion of approximately 15% of records. In all cases birth years of centenarians agreed well with information reported in 1880, 1900 or 1910 censuses (as well as information about birth years of siblings). In addition to that, partial verification of centenarian birth dates was already accomplished through the linkage to DMF.

Life Span Data Reconstruction for Siblings and Spouses. Birth dates were reconstructed for all centenarian siblings using information available in computerized genealogies and early censuses. The procedure of death date verification using DMF is not feasible for validating death dates of shorter-lived siblings or spouses (used as controls), because data completeness of DMF is not very high for deaths occurred before the 1970s (Faig 2001). State death indexes, cemetery records and obituaries cover longer periods of time. Taking into account that exact ages of death for controls (siblings) are not particularly important for comparison (it is sufficient to assume that they lived less than 100 years) we relied on death date information recorded in family histories for siblings and spouses not found in external sources. This approach was used previously in the Utah Population Database study for individuals died before 1932 (Kerber *et al.* 2001). Death dates were reconstructed for 99.99% of siblings using the Social Security Death Master File, state death indexes and online genealogies (only 124 out of 13,654 cases were left unresolved).

Statistical Methods. Student t-test was used to compare mean life spans. Gompertz regression models were used to model survival time between age 50 and death for centenarian siblings. Models for brothers and sisters were analyzed separately.

Results

Brothers of male centenarians lived significantly longer compared to brothers of female centenarians : life expectancy at age 50 was 29.01 and 26.86 respectively ($p<0.001$). Sisters of male centenarians had no survival advantage compared to sisters of female centenarians (31.26 vs 31.73 years, $p=0.24$). The sex ratio for siblings surviving to age 50 years is higher (more males) in families with male centenarian (sex ratio = 1.22), when compared to the sex ratio in families with female centenarian (sex ratio = 1.10). In addition to brothers, fathers of male centenarians demonstrate significant survival advantage compared to fathers of female centenarians: life expectancy at age 50 equal to 27.22 vs 25.97 ($p=0.04$). This effect is gender-specific and is observed for fathers of male centenarians but not for mothers who have similar survival with mothers of female centenarians (28.26 vs 27.28, $p=0.14$).

Figure 1 shows survival after age 40 for male siblings of centenarians depending of centenarian gender. Note that brothers of male centenarians have substantially better survival, particularly after age 65 years while before the age 50 differences in survival do not exist. This suggests that having a centenarian brother has very favorable effect on late-life survival.

Table 1. Life expectancy at age 50 for siblings and parents of centenarians, by centenarian gender.

Relatives	Male centenarians		Female centenarians		P-value
	N	LS50	N	LS50	
Brothers	1254	29.01	4018	26.86	<0.001
Sisters	1029	31.26	3666	31.72	0.241
Fathers	419	27.22	1364	25.97	0.043
Mothers	402	28.26	1341	27.28	0.143

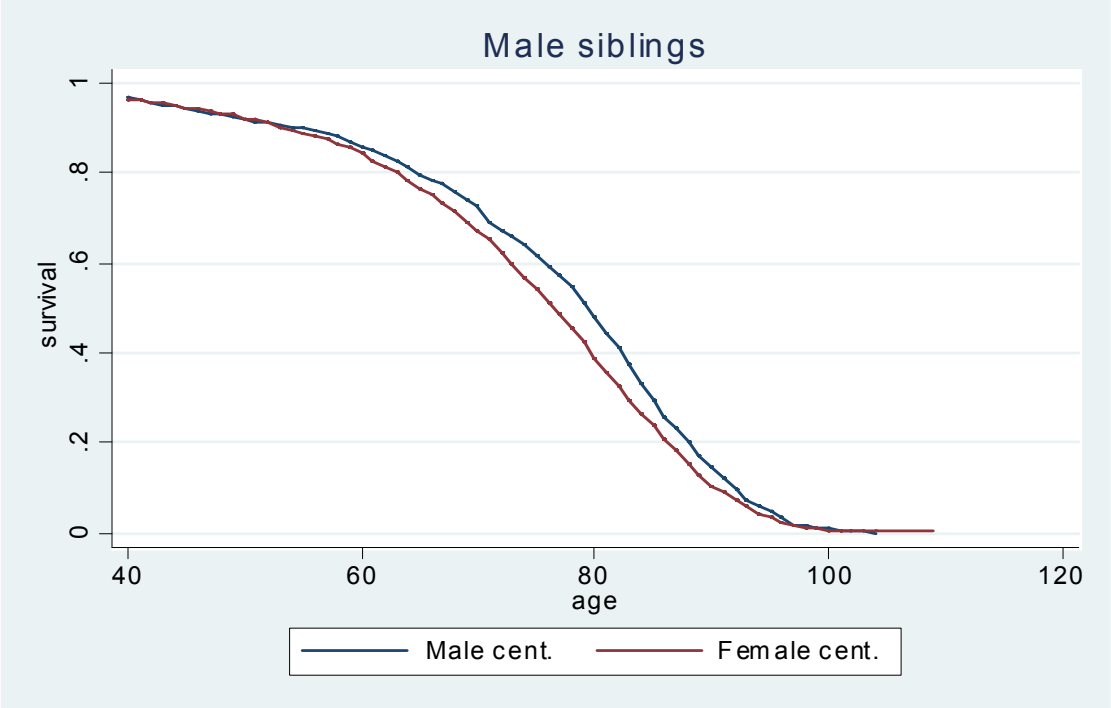

Figure 1. Survival of male siblings of centenarians, by centenarian gender.

Table 2. Multivariate survival analysis. Gomperz hazard regression model for survival of centenarian brothers and sisters after age 50[†].

Covariate	Hazard ratio	95% CI	P-value
Centenarian Brothers (N = 5,287)			
Father lived 80+	**0.889**	**0.841-0.939**	**<0.001**
Mother lived 80+	**0.930**	**0.881-0.983**	**0.009**
Sibship size	0.993	0.983-1.004	0.220
Female sex of centenarian	**1.177**	**1.105-1.255**	**<0.001**
Centenarian Sisters (N = 4,849)			
Father lived 80+	0.976	0.921-1.033	0.396
Mother lived 80+	**0.932**	**0.880-0.987**	**0.015**
Sibship size	**1.012**	**1.001-1.023**	**0.038**
Female sex of centenarian	1.012	0.945-1.084	0.726

[†] Controlled for month of birth and paternal age (NS).

These results were confirmed in multivariate model of sibling survival after age 50 when controlling for family size, parental age, parental longevity and centenarian sex. In multivariate models the effect of centenarian gender was significant only for brothers (male sex of centenarian decreased hazard rate ratio) but not for sisters. Paternal longevity (lifespan over 80) significantly improved survival of brothers but not survival of sisters. Maternal longevity had weaker but statistically significant effect on survival of both brothers and sisters. For sisters, centenarian gender had no significant effect on survival after age 50 years.

Hypothesis 1.

One possible explanation of this phenomenon is that male and female centenarians have different survival threshold to reach age 100 because of lower female mortality. Thus, male centenarians may be genetically more robust and hence their relatives live longer compared to female relatives. In order to test this hypothesis, we compared siblings of male centenarians to siblings of females survived to age 103. Probability of survival to 103 for females is even lower than the same probability to reach age 100 for males (according to the 1900 U.S. cohort).

Table 3. Life expectancy at age 50 for siblings and parents of centenarians having similar survival threshold, by centenarian gender.

Relatives	Male centenarians		Female centenarians survived to age 103		P-value
	N	LS50	N	LS50	
Brothers	1254	29.01	974	27.23	0.0002
Sisters	1029	31.26	887	32.27	0.053
Fathers	419	27.22	369	25.81	0.085
Mothers	402	28.26	369	27.68	0.504

Table 3 shows that even with the same survival threshold brothers of male centenarians have significantly higher life expectancy at age 50 compared to brothers of females living to 103+ years. At the same time, the sisters of these longevous females have slightly higher life expectancy compared to sisters of male centenarians.

Hypothesis 2. Taking into account that centenarian female gender has a much weaker effect on survival of sisters compared to the similar effect of centenarian male gender on the survival of brothers we may hypothesize that male centenarians and their brothers share living conditions favorable for men. To test this hypothesis, we used data on life expectancy for centenarian siblings-in-law as a control group. Siblings-in-law do not share genetic background and living conditions with centenarians but they usually come from the same socio-economic background. Table 4 shows life expectancy at age 50 years for centenarian siblings and siblings in law depending on centenarian gender. Note that centenarian gender has no effect on life expectancy of centenarian siblings in law. This result suggests that survival advantage of centenarian brothers is not related to better socio-economic status of male centenarians and their brothers compared to brothers of female centenarians.

Table 4. Life expectancy at age 50 for married siblings and siblings in law, by centenarian gender.

Relatives	Male centenarians		Female centenarians		P-value
	N	LS50	N	LS50	
Brothers	784	29.53	2437	27.12	<0.001
Sisters	650	31.36	2378	32.40	0.045
Brothers in law	492	24.95	1857	25.06	0.846
Sisters in law	611	29.22	1796	29.55	0.539

One possible explanation of the observed phenomenon comes from the past family traditions. In the past, men often continued to live in the place of their childhood while women more often left parental household. Favorable living conditions and/or lifestyle of male centenarians could be more likely shared by their brothers rather than sisters as well as by their spouses. If this hypothesis is correct, then spouses of male centenarians (wives) should have higher life expectancy compared to wives of centenarian brothers. Table 5 shows results that confirm this hypothesis. In this case, females rather than males have higher life expectancy. Thus, we may suggest that living in household with better environment and healthier lifestyle has positive effect on survival of both husbands and wives.

Table 5. Life expectancy at age 50 for centenarian spouses and spouses of centenarian siblings, by gender.

Relatives	Centenarian spouses		Siblings in law		P-value
	N	LS50	N	LS50	
Men	876	25.38	2349	25.04	0.442
Women	283	31.40	2407	29.46	0.007

These findings are consistent with our previous results as well as results of other studies, which showed positive effects of farming and farm background on late-life survival (Preston *et al.* 1998; Gavrilova & Gavrilov 2007). Farm background turned out to be particularly favorable for men who usually continue to work on farm. This study suggests that a significant portion of lifespan advantage for siblings of centenarians may be related to better lifestyle and living conditions rather than common genetic background.

Conclusions

Male sex of centenarians had significant effect on survival of male relatives (brothers and fathers) but not on survival of female relatives. Study of centenarian gender effects on survival of relatives suggests that environmental conditions and lifestyle may play more significant role in exceptional longevity than it was thought before.

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